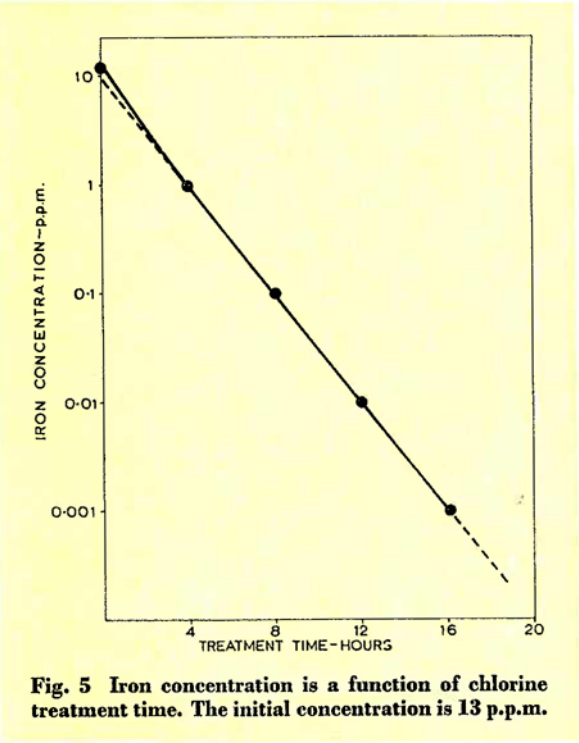

Fig. 5 Iron concentration is a function of chlorine treatment time. The initial concentration is 13 p.p.m.

unfortunately is no longer true below 1 p.p.m. so that we must use the anomalies themselves. The residual resistivity is not a very sensitive tool, since it includes all types of scattering outlined above and the effects of a few parts per billion of iron will not show up. Fortunately the thermopower is different: the Nordheimer-Gorter rule states that for two scattering mechanisms, the thermopower is (8)

$$S=(S_1\rho_1+S_2\rho_2)/(\rho_1+\rho_2)$$

If 1 refers to magnetic scattering and 2 to all other processes, then theory (9) gives

$$S_2\simeq 3\times 10^{-2}\mu V/K \text{ at } 4\ K$$

$$\text{while } S_1\simeq 20\ \mu V/K$$

and for Au–Fe this reduces to

$$S\simeq 8\ c/\rho\ \mu V/K$$

where c is in p.p.m. and ρ in nΩ cm

The following table applies to actual measurements made by the writer (7):

	Thermopower μ(V/K)		
c(p.p.m.)	T=1 K	T=4 K	T=10 K
10	−5.5	−5.5	−5.2
1	−1.7	−1.7	−1.6
0.1	−0.18	−0.17	−0.14
0.01	−0.01	−0.01	+0.03

As this table indicates, the thermopower is almost temperature independent except for a slight reduction at higher temperatures. A simple measurement of S and ρ will give c, at least in the range from 0.01 to 10 p.p.m. Below 0.01 p.p.m. it becomes very difficult to pick up the effects of the iron. This is not surprising since the mean distance between the impurities is about 400 lattice spacings. Above 10 p.p.m. the ordinary methods of analysis are sufficient.

Conclusions

Magnetic impurities behave differently from other defects in metals like gold. They are able to influence electronic properties down to the part per billion level. These changes themselves can be used to determine the impurity concentration below 10 p.p.m. where chemical methods begin to fail. The thermopower is not too difficult to measure and affords the best means of testing for such impurities. It is possible, in the case of gold, to remove the iron selectively by a treatment with chlorine. In this way the iron concentration of a single specimen may be progressively reduced to a very low level.

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The latest in a series of Mineral Dossiers—reports on minerals of economic importance to Great Britain—is concerned with gold. Compiled by Dr R. S. Collins of the Institute of Geological Sciences, it assembles information not normally brought together and covers a wide range of interests, starting with the properties of gold and its mineralogy and mode of occurrence with particular reference to the small resources of gold in the United Kingdom.

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